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(54) Service advertisements in wireless local networks

(57) Scheme for advertising service offerings in a communications system comprising two devices, wherein a first of said two devices

a. sends service information, comprising information about itself and/or other known devices

i. chose timeout value T_A,

ii. listen for up to maximum time T_A for service information sent by another device,

iii. if T_A timed out, continue with step a.
otherwise, check whether said service information sent by another device comprises information about itself (local services); if yes, then continue with step i.; if no, then continue with step a.

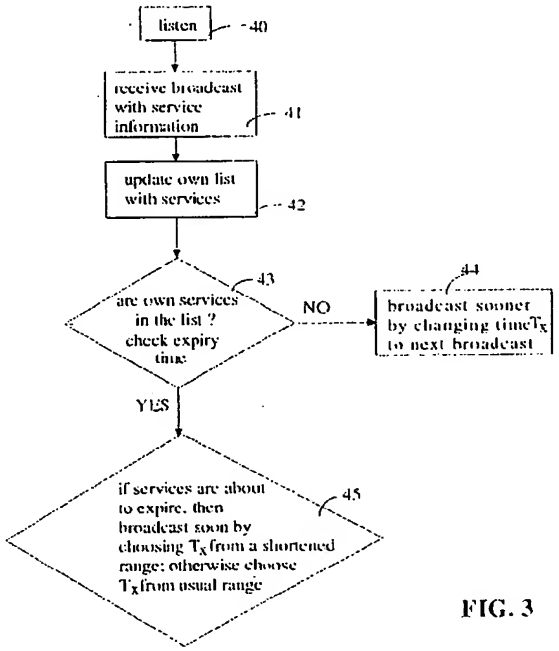

FIG. 3

EP 1 022 876 A1

Description

TECHNICAL FIELD

[0001] The invention concerns wireless local area networks and the communication between the devices forming such a network. More specifically, the present invention relates to a communication scheme which allows devices within the wireless local area network to announce their service and/or to discover services provided by other devices.

BACKGROUND OF THE INVENTION

[0002] Computer terminals and peripherals have become dramatically smaller and more portable. Personal computers and peripherals are small enough to sit on the desk at work. Smaller still are lap top computers and notebook computers. There are computer terminals which are small enough to be mounted in a vehicle such as a delivery truck. Still smaller are the hand held terminals typically used for their portability features where the user can carry the terminal in one hand and operate it with the other. A physical connection of the above devices by means of cables or fibers might have drawbacks, such as configuration constraints because of the limited length of the cable, limited number of ports on the computer thus limiting the number of peripherals that can be attached, cumbersome reconfiguration of hardwired devices, etc. Note that there are some cable or fiber based communication systems where the limited number of ports on the computer does not really limit the number of peripherals. Ethernet is one example of a communication system where the cable is used as a shared medium (other examples are token ring, FDDI (Fiber Distributed Data Interface), and DQDB (Distributed Queue Dual Bus)).

[0003] The smaller the devices get, the more important it becomes to replace fixed physical connections by wireless ad-hoc connections (e.g. body networks, radio frequency connections, or infrared connections), since physically connecting the computer terminals, peripherals, and other devices by means of cables or fibers severely reduces the efficiency gained by making the units smaller. Ad-hoc connections are required where devices move around, enter an area and exit the area. The term ad-hoc refers to the need for frequent network reorganization.

[0004] Local area communication is rapidly evolving into what can be called personal local area networks, which are networks for communication between local peers or subsystems. These kind of networks will herein be referred to as local networks. Wireless communication is of particular importance in such local networks. There are different wireless communications approaches known that have been developed and designed with an eye on the communication between peers or subsystems of such local networks.

[0005] A typical example of a local network is the personal area network (PAN) which grew out of work between two research groups at the Massachusetts Institute of Technology's (MIT) Media Laboratory. The PAN technology uses a tiny electrical current to transmit a user's identification and other information from one person to another, or even to a variety of everyday objects such as cars, public telephones and automated teller machines (ATMs). Information is transferred via microprocessors that are placed in PAN transmitters and receivers the size of a thick credit card. The digital data is then sent or received via a tiny external electric field. The small signal is conducted by the body's natural salinity and carries the information, unnoticed, through the body. The natural salinity of the human body makes it an excellent conductor of electrical current. The PAN technology takes advantage of this conductivity. The low frequency and power of the signal ensures that the information, which is coded to the individual, does not travel beyond the body and can only be received by something, or someone, in contact with it. The speed at which the information is currently transmitted is equivalent to a 2400-baud modem. Theoretically, 400,000 bits per second could be communicated using this method. The PAN is a typical example of an ad hoc body network which does not require any fixed cabling or the like.

[0006] The PAN technology has potential applications in business, medical, retail and even in personal arenas. Business associates could, for example, exchange electronic business cards with a handshake. Corporate security devices could automatically log users on and off computer systems and subway commuters could pay for a ride by walking through a turnstile. PAN technology could also enable people to carry digital versions of their medical files for instant access by emergency medical technicians; calling card numbers could automatically be sent from a wallet to a payphone; and ATMs and automobiles would be able to immediately distinguish their owners as they approach. Another application area is with traders, requiring fast and reliable log on/off on the trading floor for entering purchases and sales. Even household devices, such as CD players, televisions and toasters, could identify and adapt to individual preferences and tastes using PAN technology. The PAN networks are usually point to point where the human body serves as kind of a broadcast communications medium.

[0007] GTE Corporation has developed a short-range radio-frequency (RF) technique which is aimed at giving mobile devices such as cellular phones, pagers and handheld personal computers (PCs) a smart way to interact with one another. GTE's technique is tentatively named Body LAN (local area network). The original development of Body LAN was via a wired vest with which various devices were connected (hence the name Body LAN). This graduated to an RF connection a couple of years ago.

[0008] Xerox Corporation has developed a handheld computing device called PARC TAB. The PARC TAB is

portable yet connected to the office workstation through base stations which have known locations. The PARC TAB base stations are placed around the building, and wired into a fixed wired network. The PARC TAB system uses a preset knowledge of the building layout and the identifiers of the various base stations to decide where it is by the strongest base station signal. A PARC TAB portable device has a wireless interface to the base stations. The PARC TAB system assumes that the PARC TAB portable device is always connected to the network infrastructure. The location of each portable PARC TAB device is always known to the system software. The base stations establish regions and are connected to power supplies. PARC TAB communication systems have a star topology.

[0009] In an attempt to standardize data communication between disparate PC devices several companies, including Ericsson, IBM, Intel, Nokia, and Toshiba established a consortium to create a single synchronization protocol (code-named Bluetooth) to address problems arising from the proliferation of various mobile devices. There are many other adopter companies. The proposed solution would automatically synchronize mobile devices when end-users enter their offices. Enabling seamless voice and data transmission via wireless, short-range radio, the Bluetooth technology will allow users to connect a wide range of devices easily and quickly, without the need for cables, expanding communications capabilities for mobile computers, mobile phones and other mobile devices. The Bluetooth operating environment is not yet fully defined, but there are expected to be similarities with the IrDA (Infrared Data Association) specification and the Advanced Infrared (AIr) specification. Other aspects that probably will find their way into Bluetooth might stem from the IEEE standard 802.11 and/or HIPERLAN, as promulgated by the European Telecommunications Standards Institute (ETSI).

[0010] Bluetooth radio technology provides a mechanism to form small private ad-hoc groupings of connected devices away from fixed network infrastructures. Bluetooth makes a distinction between a master unit - which is a device whose clock and hopping sequence are used to synchronize all other devices - and slave units in the same network segment. In other words, the Bluetooth approach is centralized. A query-based discovery scheme is used for finding Bluetooth devices with an unknown address. Queries are also centralized at a registry server. It is a drawback of such a centralized approach that there is a central point of failure. It is another disadvantage of such a system that more overhead is required than in a distributed scheme. The main problem of such a system is in locating a single registry server, and what to do if it disappears. If a random two devices encounter each other they must first recognize each other's presence, then decide which is the registry server, and then go about their business of communicating. It is this continual selection and re-selection of a leader that causes the increased overhead. The alternative is to expect users to carry one device that they always have with them, and make it always the leader. This, however, is not always a practical option. Further details can be found in Haartsen, Allen, Inouye, Joeressen, and Naghshineh, "Bluetooth: Vision, Goals, and Architecture" in the Mobile Computing and Communications Review, Vol. 1, No. 2. Mobile Computing and Communications Review is a publication of the ACM SIGMOBILE.

[0011] HomeRF (based on Shared Wireless Access Protocol (SWAP) is another example of an operating environment which can be used to connect devices. A HomeRF Working Group was formed to provide the foundation for a broad range of interoperable consumer devices by establishing an open industry specification for wireless digital communication between PCs and consumer electronic devices anywhere in and around the home. The working group, which includes the leading companies from the personal computer, consumer electronics, peripherals, communications, software, and semiconductor industries, is developing a specification for wireless communications in the home called the SWAP. The HomeRF SWAP system is designed to carry both voice and data traffic and to interoperate with the Public Switched Telephone Network (PSTN) and the Internet; it operates in the 2400 MHz band and uses a digital frequency hopping spread spectrum radio. The SWAP technology was derived from extensions of existing cordless telephone (DECT) and wireless LAN technology to enable a new class of home cordless services. It supports both a time division multiple access (TDMA) service to provide delivery of interactive voice and other time-critical services, and a carrier sense multiple access/collision avoidance (CSMA/CA) service for delivery of high speed packet data. The SWAP system can operate either as an ad-hoc network or as a managed network under the control of a connection point. In an ad-hoc network, where only data communication is supported, all stations are equal and control of the network is distributed between stations. For time critical communications such as interactive voice, the connection point - which provides the gateway to the PSTN - is required to coordinate the system. Stations use the CSMA/CA to communicate with a connection point and other stations. Further details about HomeRF can be found at the Home Radio Frequency Working Group's web site http://www.homerf.org. The SWAP specification 1.0 is incorporated by reference in its entirety.

[0012] The above-mentioned IEEE 802.11 standard for wireless LAN medium access control comprises features for conserving power. At regular intervals, with small random time offsets, LAN members broadcast information about themselves only. If a device receives such a broadcast while it is preparing one itself, it will not broadcast that round. In this way, all devices broadcast their individual characteristics with statistically even distribution. Because the medium access control

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(MAC) layer is given specific addresses to which it directs transmissions, its image of the LAN does not always need to be up-to-date. It is a clear disadvantage of the approach promulgated in IEEE 802.11 that it might take some time until a newly arrived device or an absent device is announced/noticed. IEEE 802.11 LANs are centralized, star-shaped networks. It should also be noted that the 802.11 advertisements are only about communications characteristics and individual identity, not service offerings.

[0013] There are several more or less elaborate protocols and techniques that allow an ad-hoc wireless communication between mobile devices. The above described Bluetooth radio technology and HomeRF approach are prominent examples. All state-of-the-art protocols and techniques have certain drawbacks, as briefly addressed in the following section.

[0014] For seamless connection in an ad-hoc local network, the respective devices require a method for becoming aware (discovery) of the services offered by neighbours. In addition, the devices in such a network must make their own services known (advertisement). On one hand, the discovery and advertisement of services offered in a local network must be carried out in a timely manner, but on the other hand battery power must be conserved if portable devices are employed. It is a further requirement for a local network that entering the network is seamless such that the device can easily change locations. It is desirable that no user intervention is required if a device enters or leaves an ad-hoc network. It would be arduous if the user would have to push a button for every reconfiguration, for example. It is also desirable that a device should be able to leave the network without formal notification.

[0015] It is an object of the present invention to provide a scheme for introducing a new device into an ad-hoc wireless local network.

[0016] It is an object of the present invention to provide a scheme for a device of an ad-hoc wireless local network to announce its services to another device of the local network.

[0017] It is an object of the present invention to provide a scheme for a device of an ad-hoc wireless local network to discover services provided by other devices of the local network.

SUMMARY OF THE INVENTION

[0018] The present invention concerns an apparatus for exchanging service information with other devices. The present apparatus comprises a transceiver, a processing unit, a memory for storing information about its local services and/or services provided by other devices, and a protocol resource manager. This protocol resource manager

a. triggers the transceiver to send service information, comprising information about itself and/or other known devices to other devices,

b. chooses a timeout value T_A,

c. ensures that the apparatus listens for up to a maximum time T_A for service information received by said transceiver,

d. if T_A timed out without having received such service information by said transceiver, triggers said transceiver to repeat step a.,

e. if such service information was received by said transceiver prior to T_A timing out, checks whether said service information received comprises information about itself; and

f. if yes, then chooses another timeout value T_A, and continuing with step c,

g. if no, then continues with step a.

[0019] The present invention also concerns a scheme for advertising service offerings in a communications system comprising two devices, wherein a first of said two devices

a. sends service information, comprising information about itself and/or other known devices

i. chose timeout value T_A,

ii. listen for up to maximum time T_A for service information sent by another device,

iii. if T_A timed out, continue with step a.
otherwise, check whether said service information sent by another device comprises information about itself (local services); if yes, then continue with step i.; if no, then continue with step a.

[0020] The present invention relates generally to local networks and, more specifically, to a communication scheme which allows devices within the local network to announce their service and/or to discover services provided by other devices while limiting the power drain of battery powered devices. The present local networks typically have a hybrid mesh topology where a device communicates with any other device. No base station or master device is required. A peripheral device for instance can communicate with another peripheral device without any relay station or base station being involved.

[0021] The present solution combines advertisements and/or discovery with membership renewals. The general approach is that a group of devices will take turns broadcasting (advertising) a list of services (herein referred to as service information) available. By using variable transmission delays that are reset when other advertisements are seen, and adjusting the distribution

of these delays, new devices can quickly be identified, and absent machines can be noticed. The present invention provides a mechanism to form small private ad-hoc groupings of connected devices away from fixed network infrastructures. With this invention, a solution is presented that, when used in combination with a wireless communications protocol, allows to set up local networks immediately (ad-hoc) if needed, and to take them down if not needed anymore. According to the present invention a network of all eligible proximate devices (devices that will allow themselves to be networked) can be set up while allowing new devices to join and leave at their own convenience.

[0022] All devices that form an ad-hoc grouping, according to the present invention, do not necessarily have to have identical implementations (from a software and/or hardware point of view) as long as at least the present service discovery protocol is implemented in all these devices.

[0023] One device might act as a master and the other (s) as slave(s).

[0024] A device might be put into a power-saving mode in which the device activity is lowered.

[0025] It is an advantage of the present scheme that battery power is conserved by using only a small number of transmissions.

[0026] The present scheme facilitates implementations where the entering of a local network is seamless in that it does not require user intervention. The present scheme also facilitates implementations where a device is able to leave a local network without formal notification.

[0027] Further advantages are (not all of these advantages have to be realized in an implementation of the present scheme): the local area network automatically adjusts itself to any changes; the traffic volume is kept low; a device within a local network according to the present invention may change place in real time, a device may turn on or off arbitrarily, while the other devices within vicinity monitor its appearance/disappearance on the network without posing interference to any ongoing communication.

DESCRIPTION OF THE DRAWINGS

[0028] The invention is described in detail below with reference to the following schematic drawings. It is to be noted that the Figures are not drawn to scale.

FIG. 1 is a schematic block diagram of a first embodiment, in accordance with the present invention.

FIG. 2A is a schematic representation of a local network, in accordance with the present invention.

FIG. 2B is an example of local service lists (at t=0) used in connection with the present invention.

FIG. 2C is an example of a packet or frame used in connection with the present invention.

FIG. 2D is an example of local service lists (at $t=t_2$) used in connection with the present invention.

FIG. 2E is an example of another packet or frame used in connection with the present invention.

FIG. 2F is an example of local service lists (at $t=t_4$) used in connection with the present invention (with $t_1<t_2<t_3<t_4<t_5<t_6$).

FIG. 3 is a schematic flowchart used to described aspects of the present invention.

FIG. 4 is another schematic flowchart used to described aspects of the present invention.

FIG. 5 is another schematic flowchart used to described aspects of the present invention.

FIG. 6A is a schematic representation of another local network, in accordance with the present invention.

FIG. 6B is an example of a local service list (at $t=t_5$) used in connection with the present invention.

FIG. 6C is an example of a local service list (at $t=t_6$) used in connection with the present invention (with $t_5<t_6$).

DESCRIPTION OF PREFERRED EMBODIMENTS:

[0029] For the purpose of the present description, a local network is defined as being a network composed of at least two devices within mutual communication range of each. Within such a local network the devices communicate with each other without the need for a wired network The local network might be established by means of infrared (IR), radio-frequency (RF), HomeRF, or other means, such as the user's body, as in case of the PAN, for example. A local network does not need to have an access point for connection to a fixed network. The local network may be completely isolated from any other network, or it might comprise one or more access points which provide the (wireless) devices with access to the wired network.

[0030] The specific range that constitutes a local network in accordance with the present invention depends on actual implementation details. Generally, a local net-

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work can be described as having a a coverage area between a few square meters and a few hundred square meters. Under certain circumstances the communication range might even go beyond.

[0031] The present networking scheme can be used in warehouses, on manufacturing floors, in offices, on trading floors, in private homes, in cars and trucks, in airplanes, and outside of buildings, just to mention some examples.

[0032] When referring to a device, any kind of device is meant that can be a member of a local network. Examples of devices are: laptop computers, workpads, nodepads, personal digital assistants (PDAs), notebook computers and other wearable computers, desktop computers, computer terminals, networked computers, internet terminals and other computing systems, set-top boxes, cash registers, bar code scanners, point of sales terminals, kiosk systems, cellular phones, pagers, wrist watches, digital watches, badges, and smart cards. Other contemplated devices include: headsets, Human Interface Device (HID) compliant peripherals, data and voice access points, cameras, printers, fax machines, keyboards, joysticks, kitchen appliances, tools, sensors such as smoke and/or fire detectors, and virtually any other digital device.

[0033] Other examples of wearable computers that can be used in connection with the present invention are, personal effects being equipped with computer-like hardware, such as a "smart wallet" computer, or articles of clothing. In addition to a "smart wallet" computer, there are a number of other variations of the wearable computers. A "belt" computer is such a variation which allows the user to surf, dictate, and edit documents while they are moving around. Yet another example is a kids' computer which is comparable to a personal digital assistant for grade-school children. The kids' computer might hold assignments, perform calculations, and help kids manage their homework. It can interface with other kids' computers to facilitate collaboration, and it can access a teacher's computer to download assignments or feedback. Any wearable or portable device, any office tool or equipment, home tool or equipment, system for use in vehicles, or systems for use in the public (vending machines, ticketing machines, automated teller machines, etc.) might comprise the present invention.

[0034] The present invention requires the transmission of service information. Any kind of service description can be used to describe the services in a format which can be processed by the devices. One preferably uses a service description which is optimized so that transmissions are efficient. The service description should be flexible and extensible. In the present context the type of service is described by means of a so-called service identifier. This service identifier can be a simple flag or bit combination which describes standard types of services. for example. These standard type of services might be predefined such that they can be identified by such a simple flag or bit combination The service identifier can also be any other kind of information which is suited to identify one or several services offered. In addition to identifying a type of service, one might have to set or define certain parameters and options (for sake of simplicity hereinafter referred to as service parameters). This is now explained in connection with an example. A printer announces to another device within reach that it provides printing services by sending the respective service identifier. In addition, it might want to inform the other device that it has A4 paper in one tray and A3 paper in another tray. This information is transmitted in form of service parameters. Furthermore, security features might be built in to protect certain transmissions. An error correction scheme might be used to ensure that the transmission of service information reliable. Furthermore, the service information might comprise details on the kind of device which is offering services (for sake of simplicity hereinafter referred to as device identifier). The device identifier can be a MAC address or the like. One can also use any other scheme. Note that this is optional.

[0035] **Network topology:** The present scheme can be used in local networks with point-to-point and/or point-to-multi-point connections. Several network segments (groups) can be established and linked together ad-hoc. The network topology is lower-level than the subject of the present invention. Aspects of the network topology are only addressed to the extent necessary. Note that the present invention is independent of the network topology and can be used on any kind of network topology allowing broadcast. Most implementations of the present scheme have a mesh topology. It is also possible, however, to use the present scheme in a star-shaped or ring-shaped topology, for example.

[0036] **Network technology:** The present scheme can be used in connection with any kind of wireless communication technique, such as RF, IR, body networks (such as the PAN), and the like.

[0037] Well suited is the Bluetooth communications scheme, which is described in the Haartsen, Allen, Inouye, Joeressen, and Naghshineh, "Bluetooth: Vision, Goals, and Architecture" in the Mobile Computing and Communications Review, Vol. 1, No. 2. Mobile Computing and Communications Review is a publication of the ACM SIGMOBILE. This reference is incorporated by reference in its entirety.

[0038] The basic concept of the present invention is described in the following. An 'advertisement' is service information (e.g. a list of entries), identifying services of which the transmitting device is aware. The advertisement might include 'local services', existing on the transmitting device, and/or 'remote services' known by the transmitting device to exist on some other device with which a communication channel is known to exist (either direct, or through yet another intermediary). Service information is associated with an expiry time or a number that ages out by increasing or decreasing it. An example of a way to maintain this expiry time would be to use an

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absolute time of day, and include the local clock value at the time of transmission in each advertisement, allowing other devices to adjust the times to their local clocks.

[0039] Each device will, from time to time, send its own service information (e.g. a list of entries) as an advertisement (the service information might include other known services, but not update their timeout values). The probability of a device sending an advertisement will depend partially on the time since the last advertisement is known to have been broadcast (sent and/or received). The advertisement might include the latest known expiry time values for services (setting expiry times for its own service in the process). If a device sees that its local services will timeout soon, it might adjust its broadcast delay distribution to make it more likely to transmit soon (thus renewing the expiry times of its local services).

[0040] The present scheme does not foresee any master device or base station. According to the present invention no such base station is required. The present scheme works everywhere provided that there are at least two devices that support the present scheme.

[0041] When an advertisement is received (discovery), the receiving device updates an internal list of available services from the received service information. This involves updating timeouts for services already known, (i.e. setting local entries' times to the earlier value, and remote entries' times to the later value) and adding entries for new services. This would also be a good time to remove expired entries.

[0042] The present scheme is asymmetric in that a typical device is mainly listening. This is advantageous because receiving (discovering) advertisements consumes less battery power than actively sending advertisements. Asymmetric thus means that a typical device receives advertisements from other devices more often than it sends own advertisements. Note that a device in listening state does not necessarily have to listen all the time. To conserve power an unconnected device might periodically listen for advertisements from other devices, for example.

[0043] As an example of how the present scheme can be used to conserve power, a network with several battery-powered devices and one that is connected to a power grid is considered. If the device with a better power source (in the present example the one device that is connected to the power grid) has a mean time of five seconds between receiving (discovery) or sending an advertisement, and the other devices have a mean of seven seconds, then most transmissions will be from the device that can afford the power cost. As the other devices notice that their entries are close to expiring, they can alter their transmission probability distribution to make it more likely that they will send an advertisement soon. In this way, they transmit only occasionally, conserving battery power, but if they are removed from the network, their absence will be missed (as they will no longer be renewing their entries' expiry times). By adjusting the expiry time of different devices, the frequency with which such updates must be sent can also be adjusted to balance the power requirement with the frequency with which certain devices may be expected to leave the local network.

[0044] The systems according to the present invention are completely distributed - at least as far as the advertisement and/or discovery of services is concerned - because no device is more important than any other device. Local network partitions or the loss of a single device will not affect the robustness of the network. New devices will promptly receive a full list of services (discovery) available in a new network segment. This may happen before the new device even realizes that it has entered a new segment. This is an advantage, because it means that the membership algorithm does not have to sense when an area (segment) has been left or entered. This makes its state independent of its environment, and makes the algorithm much easier to implement.

[0045] The IEEE 802.11 standard for wireless LAN medium access control has features that allow to conserve power, too. According to this standard, IEEE 802.11 LAN members broadcast information about themselves at regular intervals, with small random time offsets. These LAN members broadcast only information about themselves. They do not advertise information about the services offered by other devices. If an IEEE 802.11 LAN member receives such a broadcast while it is preparing one itself, it will not broadcast that round. In this way, all devices broadcast their individual characteristics with statistically even distribution. Note that the present approach is different in that the advertisements occur in a non-even statistical distribution. In other words, if one describes the probability of having transmitted an advertisement as a function of time, assuming that no other advertisements are transmitted, the present scheme would not necessarily produce the same curve for all devices. The probability of any particular device transmitting an advertisement during a given "advertising cycle" would be 1/n for n devices operating in an IEEE 802.11 network, but might be different for each device operating in a network in accordance with the present invention. This is an interesting feature because it allows weaker devices, i.e. those devices that have less available power, to advertise less frequently.

[0046] Because the IEEE 802.11 MAC layer is given specific device addresses to which it directs transmissions, its image of the LAN does not need to be as timely as the present algorithm. The chief difference is that in the present algorithm, the full list is more quickly communicated to new arrivals, and absent devices are more quickly identified.

[0047] In the following an exemplary implementation (first embodiment) of the present scheme is described in connection which Figure 1. In this Figure a schematic block diagram of the components of a device 10 - in

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which the present invention is implemented - is shown. The device 10 comprises a transmitter 13 for sending information via an output channel 21 to another device, and a receiver 14 for receiving through an input channel 22 information from another device. Note that in the present example there are two channels 21, 22 shown. These channels can be any kind of shared media channel, such as an IR, RF, or body network channel, for example. These channels do not have to be the same. It is conceivable that the output channel 21 is an infrared channel whereas the input channel 22 is a RF channel.

[0048] The transmitter 13 and receiver 14 communicate with a medium access control (MAC) unit 12. The MAC layer is well defined by international standards (cf. ISO OSI (Open Standards Interconnection) reference model as described in A.S. Tannenbaum's book "Computer Networks", for example) and the MAC unit 12 might be a conventional unit employed in communication systems to control the MAC layer. Note that a MAC layer is a logical division, and would be only logically divided from other parts of the protocol implemented at 11 on the same physical device. The MAC unit 12 might be employed to detect and/or avoid collisions. In the present embodiment the MAC unit 12 is used to send and receive broadcast packets. The device 10 has a power supply 15. In the present example the power is provided by a battery. Likewise, the power might be provided by via a power plug, a solar cell, or the like. The power supply provides power to the components of the device 10. For sake of simplicity, the respective circuit lines or cables are not shown in Figure 1.

[0049] Meta data are fed from a meta data protocol resource manager 11 to the MAC unit 12. "Meta Data" refers to information about the protocols and/or services, as opposed to "User Data", which is useful to applications, for example. In the present context, meta data mainly refers to services (e.g. provided in form of a list of services). The meta data protocol resource manager 11 is connected to a memory 16 and a central processing unit (CPU) 17. The resource manager 11 communicates by means of application programming interfaces (APIs) 19 with other units such as higher protocol blocks 18, applications 23, or services 24. The units 18, 23, and 24 are shown in Figure 11 to indicate that the present scheme enables lots of different protocols and/or applications and/or services. These protocols and/or applications and/or services can be build on top of the present scheme.

[0050] Note that the MAC 12 and the resource manager 11 are logical constructs. They could be implemented on separate devices, but they can equally well be incorporated into a program stored in memory. If incorporated into a program the device 10 might physically be the same as any other conventional device, except for the fact that it comprises the above-mentioned program. This program comprises instruction that, if processed by the CPU 17, make the device 10 perform the steps according to the present invention.

[0051] The MAC unit 12 also receives normal data (herein referred to as user data) via line 20. The resource manager 11 implements at least part of the present service exchange, allowing the services to be discovered and matched in useful ways by exchange of meta data (service information); the actual transmission of user data might be the same as ever.

[0052] To draw an analogy, consider a pay-phone: When one lifts the handset, a tone is sent to the switch, causing it to reserve a transceiver at the switching station for managing communication with that remote unit (the pay-phone). One then puts money into the phone, causing more tones to be sent to the switch to identify the amount. These tones are acknowledged using more special tones. Based on this information, a service connection is made. Now user data (your destination phone number) also uses special tones, but these are part of a different (higher-level) protocol common to all phones, regardless of underlying billing system, etc. This is user data, as is the analogue voice transmission that follows. At the end of the call, more tones from the switch tell the phone to swallow the money. The user does not care how this protocol works. The only important thing about it is that the correct amount is charged, and that a connection is established.

[0053] Similarly, the present service (resource) discovery scheme uses the same communication channel as the user data, but sends information about the services that are available (meta data; service information) rather than information actually used by those services (user data). Information is usually transferred in packets that are labeled with some destination information. If this information marks them as relating to resource availability, they will be routed through 11. If they are marked for user applications, they will bypass 11 via line 20 directly to the applications, services, and higher protocols identified as 18, 19, and 24.

[0054] Note that there is no clear distinction between services and applications. Some services are applications, but not all applications are services. In other words, services are a subset of applications.

[0055] Those skilled in the art will understand that the device 10 illustrated in Figure 1 is but one example of a device implementing the present invention and that the configuration and construction of the various elements of the device 10 uses well-known hardware and/or software. Those skilled in the art will recognize that many modifications and changes can be made to the particular embodiment described in connection within Figure 1 without departing from the spirit and scope of the invention.

[0056] An algorithm in accordance with the present invention is addressed hereinafter. Aspects of this algorithm are illustrated in form of flow charts. Note that certain steps shown in the flow chart do not necessarily have to be executed/performed in the given order. The present algorithm combines data advertisements with membership renewals. The general approach is that the

devices of a group of devices will take turns broadcasting service information comprising information about available services. By using variable transmission delays T_x that are reset using random transmission delays when another advertisement broadcast is seen, and adjusting the distribution of these transmission delays, new devices can quickly be identified and absent devices can be noticed.

[0057] The present scheme can be implemented such that a device with better power availability (e.g. a device which is connected to a power supply) broadcasts advertisements more frequently than other devices. Due to this, the bulk of transmission requirements might be shifted to devices with better power availability.

Service Advertisement Procedure

[0058] An advertisement is a message that comprises information concerning services of which the transmitter is aware, including both "local services" existing on the transmitting device (services provided/rendered by the transmitter), and "remote services" (if available), existing on some other device. Information concerning services might for example be transmitted in form of a list of entries, identifying the respective services. Entries are associated with an expiry time. An example of a way to maintain this expiry time would be to use an absolute time of day, and include the local clock value at the time of transmission in each advertisement, allowing other devices to adjust the times to their local clocks.

[0059] A typical embodiment is now described in connection with Figures 2A-2F, Figure 3, and Figure 4. A local network 30 with two devices A and B, according to the present invention, is shown in Figure 2A. There is a wireless link 34 from device B to A, and wireless link 35 from A to B. For sake of simplicity, these two devices A and B are the only devices in the local network 30. Each device comprises means to store service information. In the present embodiment the service information is stored in form of lists 31 and 32. The Figures 2B through 2F show a sequence of steps. At t=0 (Figure 2B) the service list 31 of device A contains only information concerning local services A_1 and A_2. There are no remote services know to device A. At this point in time the service list 32 of device B only comprises information concerning a local service B_1. An absolute time field is assigned to each service in the present embodiment. This time field is used to check whether local services are about to expire and if other services have expired. This field can also be used to detect whether a device is missing (e.g. because it was removed from the local network 30 because it has moved out of reach). In the present example the first transmission delay for device B has been randomly chosen to be $T_B \leq m$ (where m is the expiry time chosen by B for its services). Note that herein, although choosing a value for T_B is often referred to as "choosing a new delay T_B", T_B is compared with absolute time values, such as t and t_i. In these cases, where the value T_B is compared with time values, it refers to the time resulting from the addition of the actual delay chosen to the time at which it was chosen, i.e. the end-time of the delay. The expiry times of services, referred to in this example as m and k are not necessarily the same for all services offered by a single device, although this will often be the case. These values may be dependent on the expected mobility of the device, and will affect the number of retransmissions required, as the time between transmissions can be no shorter than the shortest expiry time of a service offered (otherwise that service might expire in the lists held at client-devices.) This step is illustrated by box 50 in Figure 4. Device B has a clock (or it receives a clock signal or clock information) and checks the time (see box 51). If $t = t_1 \geq T_B$ then the device B broadcasts service information via channel 35, as indicated by box 52. If a broadcast from another device (e.g. device A) would have been received before $t = t_1$ was reached, then a new random transmission delay T_B would have been chosen by device B, as indicated by loop 53 in Figure 4.

[0060] Device B now broadcasts service information in form of a packet or frame 33. This broadcast takes place right after the time $t = T_B$ was reached. In the present example the broadcast is assumed to occur at $t = t_1$, as shown in Figure 2C. The packet or frame 33 at least comprises information concerning the type or kind of services rendered or provided by device B, and an associated expiry time m.

[0061] The device A is assumed to have chosen a transmission delay $T_A > t_1$, which means that device A is in a listening state (box 40 in Figure 3) when device B starts to broadcast. At $t \geq t_1$ the device A receives the packet or frame 33 (box 41). Device A then updates at $t = t_2$ its own service list 31, as indicated in Figure 2D and box 42 in Figure 3. This service list 31 now comprises information concerning local services A_1 and A_2, as well as information concerning the remote service B_1. Part of the normal response by A to receiving a service list broadcast is to reset its time for the next broadcast T_A. When processing the service information received in packet or frame 33, the device A checks whether there is any information concerning its own services (box 43) in this packet or frame, and may use this information to influence its choice for the new T_A. In the present example this is not the case and device A chooses a new T_A that is earlier (on average) than the value that would have been chosen otherwise. In the present example, the new value chosen for T_A expires at t_3. In the present example, the services A_1 and A_2 expire at time $k \leq T_A$, chosen in some predefined way. The expiry of a service reflects the time after which other devices will no longer attempt to use it (assume that it is no longer available), as compared with the transmit timers (T_A and T_B here) that are internal to a device, and determine how long it will wait for an advertisement before making one itself. This step is illustrated as box 44 in Figure 3. The broadcast issued by device A is shown in Figure 2E. The pack-

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et or frame 36 now comprises information about services provided by device A and B. The packet or frame 36 is sent via channel 34 to device B. Device B is assumed to be in a listening state (box 40 in Figure 3) when device A starts to broadcast. Device B then updates at $t = t_4$ its own service list 32, as indicated in Figure 2F and box 42 in Figure 3. This service list 32 now comprises information concerning remote services A_1 and A_2, as well as information concerning the local service B_1. When processing the service information received in packet or frame 36, the device B checks whether there is any information concerning its own services (box 43) in this packet or frame. In the present example this is the case and device B chooses a new T_B from the usual (predefined) range, and waits until this transmission delay is reached before it broadcasts again. If the local services of device B are about to expire, it broadcasts sooner, e. g., by choosing a reduced transmission delay T_B from a shortened (i.e. earlier) time range. Otherwise, the transmission delay T_B is randomly chosen from the usual (predefined) time range. This is schematically illustrated by box 45 in Figure 3.

[0062] When an advertisement is received (discovery), the receiving device updates an internal list of available services from the received list. This involves updating timeouts for services already known, (e.g. by setting local entries' times to the earlier value, and remote entries' times to the later value) and adding entries for new services. This would also be a good time to remove expired entries.

[0063] The removal of services is described in connection with Figures 6A - 6C and Figure 5. Whenever a broadcast is received (box 60 in Figure 5), the list of services is updated, as discussed above. The updating is illustrated as box 61 in Figure 5. It is now assumed that device B was removed from local network 30. The local network 30 now only comprises device A, as show in Figure 6A. Device A might still be sending broadcasts, as shown by arrow 34, but no broadcasts are received from any other device. At the time $t = t_5$ the device A holds a service list 31 which is shown in Figure 6B. In the present example this list 31 is similar to the list in Figure 2D. It comprises local and remote services. Note that the remote service B_1 has an expiry time m. This expiry time is now used to remove entries of devices that have not sent any broadcast for a while, as well as entries of other remote services that have not been updated. At $t = t_6$ (with $t_6 > m$) the service list 31 of device A is updated by removing the entry or remote service B_1. The resulting service list 31 is illustrated in Figure 6C. Since there are no services of device B in the service list 31 anymore, the device A assumes that device B is not available anymore. The reason for this can be that device B has left the network 30, that it was powered down, that the link was interrupted or down, or that B may have just stopped offering service B_1 for some other reason (although B is still connected to network 30).

[0064] According to the present invention no feedback is required to acknowledge to the device that transmitted an advertisement that the respective transmission was received. A missing device can be identified by its failure to broadcast a list renewing the expiry times of its services, as will be noticed at steps 43 or 44 of Figure 3 the next time device B sends its list. The services of the missing device time out if the expiry time associated with services rendered or provided by this missing device expire. Likewise, the services of a missing device might age out by decrementing (or incrementing) a counter associated with the device's services.

[0065] Each device will, from time to time, send its own list of entries as an advertisement. The probability of a device sending an advertisement will depend partially on the time since the last advertisement is known to have been broadcast (either sent or received). These service lists will include the latest known expiry time values for all services (setting its own service expiry times in the process). If a device sees that its local services will timeout soon, it will adjust its broadcast delay distribution to make it more likely to transmit soon (thus renewing the expiry times of its local services).

[0066] When an advertisement is received, the receiving device updates an internal list of available services from the received service information. This involves updating timeouts for services already known, (e.g. setting local entries' times to the earlier value, and remote entries' times to the later value) and adding entries for new services.

[0067] Figures 2C and 2E are schematic representations of a frame or packet, in accordance with the present invention, that is transmitted by a device of a local network to announce services to all other devices that are within reach. Depending on the MAC scheme used to avoid collisions, the frame or packet might comprise a MAC layer header, for example. MAC layer headers are standardized and well known in the art. The MAC layer header might comprise information to identify the source and destination of the data packets, and might also contain other information fields (for security control, medium access management, etc.) One service announcement might be spread across multiple MAC packets.

[0068] Another implementation of the present invention is now described. Consider an example situation involving an enabled wrist watch, desktop computer, and car radio. These devices are controlled by a user. In the present implementation example, the watch normally sends an advertisement every twenty to thirty seconds, the computer every five to ten seconds, and the car radio every fifteen to twenty-five seconds. For simplicity, it is assumed that the expiry time for every service is one minute.

A. The user is in bed and the watch has not seen any service advertisements for hours. All external services in its list have expired. The watch is sending periodic advertisements, and not receiving an-

ything. The computer, unattended in the den is in the same state. Some implementations may choose to increase the delay between advertisements during these long disconnected periods, and some may choose to send empty lists (to save power) during these periods.

B. The user wakes up and goes to the den to check for e-mail and news. Eventually, an advertisement will be sent by either the watch or the computer. The other will receive this, and reset its own retransmit timer and, noticing its own services are missing from the list, will choose the new value from an earlier-than-usual range. For example, if the computer transmits first, the watch might reset itself to transmit fifteen seconds later. Since the computer will have reset its own timer to something in the range of five to ten seconds, the watch will receive another list that does not include its own services. This time, it might choose to broadcast seven seconds later. If the computer has chosen to broadcast nine seconds after its previous broadcast, then the watch will win this race, and the computer will now be aware of the watch's services.

C. Since the computer normally chooses smaller timeouts than the watch, it will continue to send a service list including both its own services and those of the watch every five or ten seconds. After nearly a minute of this, the watch will notice that its services are close to expiry, and begin to chose smaller and smaller retransmission timeouts until it eventually beats the computer to a timeout, and sends a list with both its own and the computer's services, having updated the expiry times on its own services to be a further minute into the future.

D. Reading e-mail, the user realizes an appointment in the very near future, and enters a car. When the car is started, the watch will notice the car radio. Perhaps the watch transmits first between these two. The list transmitted might still included the services of the computer, if they have not yet expired but, since the computer is no longer present to send renewals, the services will expire sixty seconds after the last advertisement actually received by the watch, and will not cause any extended confusion. The watch and radio will eventually reach a steady-state of alternating broadcasts. Since the radio will usually choose smaller timeout values, it will broadcast more frequently, but the watch will occasionally choose an earlier time, and one or the other will send a list with both sets of services every twenty seconds or so.

E. Eventually, the user arrives at the meeting and exits the car. After about sixty seconds, both lists will have expired the entries of the other, and the two devices will again be aware of only their own services.

[0069] This implementation example illustrates the purpose of the present invention and demonstrates how it can be implemented to allow different devices to exchange service information.

[0070] The present invention can be used to transfer information between all sorts of devices as exemplified by means of the following. For example, many people carry multiple electronic devices, such as cellular phones, pagers, personal digital assistants, and digital watches. If each of these was equipped with the present technology, a person could receive a page, have the name of the person paging her appear on her watch, and phone that person simply by touching the 'send' button on her cellular phone. Using PAN, for example, the pager may send the phone number through the user's body to the PDA which finds the name and sends it to her watch. Such an automation increases accuracy and safety, especially in driving situations. The present invention provides the means to exchange information about the various services and thus lays the foundations for the above outlined example.

[0071] Another application of the present scheme is to pass simple data between electronic devices carried by two human beings, such as an electronic business card exchanged during a handshake. Before the two electronic devices exchange business card information in form of user data, the respective service information and service parameters (such as the fields comprised on the business cards, for example) is to be exchanged, according to the present invention.

[0072] The present scheme may also be used in the following situation. In order to automate and secure consumer business transactions, a public phone might be equipped with means according to the present invention that would automatically identify the user, who would no longer have to input calling card numbers and PINs. An application of the present scheme significantly simplifies the exchange of service information between the devices involved and allows to inform public phone about the services provided by a device held or carried by the user and vice versa. This makes calling easier and more convenient for users.

[0073] A scheme in accordance with the present invention can also be used to alert a user via a mobile phone if an e-mail was received by their mobile PC, even while this mobile PC remains in its carrying case. When the PC receives an e-mail message, an alert will sound on the mobile phone. It is then possible to browse incoming e-mails immediately, reading the contents on the display of the mobile phone. Before all the respective user data are exchanged, a service announcement/discovery procedure according to the present invention is carried out.

[0074] It is important that all devices that are supposed to participate in the service announcement and

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discovery within a local network, support a common service announcement protocol for exchange of the service information. Once a service has been announced, some or all devices may use other protocols for exchange of application-related information (user data).

[0075] The present scheme can be further modified by adding destination information to the service announcements. This can for example be done by adding address information to the header of a service announcement. Even though all the devices of a local network may read the respective service announcement, only the addressed devices will actually process the respective service announcement.

[0076] Note that the service announcements, according to the present invention, can be transmitted at any layer of the Open System Interconnection (OSI) protocol stack. The service announcements may for example be transmitted at the network protocol layer (3rd layer of the OSI stack) either as part of a network layer header, or as an attachment to a network layer header. The present invention relates to the service announcements and is thus independent of implementation details such as the protocol layer at which the respective information is exchanged.

[0077] It is understood by those skilled in the art that at the present time many if the protocols that are suited for use in wireless communications systems are still in draft status. The present scheme is independent of any particular protocol and can be used in connection with many such protocols. Somebody skilled in the art is able to implement the present scheme in existing protocol environments as well as in protocol environments under development or yet to be developed.

[0078] The present invention enables users not only to transfer information straight from cards to palm size PCs but to synchronize entries between mobile devices and desktops.

[0079] The present invention can be used to share services, to use services provided or rendered by other devices, and to compose or combine services.

[0080] The present scheme handles devices arriving and leaving, and is further capable of finding replacement services for those that have been lost. Buffering of e-mail messages during times of disconnection or synchronizing a file system are not addressed herein, since intermittent connectivity is more of an application issue, rather than services issue.

Claims

1. Method for advertising service offerings in a communications system comprising two devices, wherein a first of said two devices

   a. sends service information, comprising information about itself and/or other known devices

   i. chose timeout value T_A.

   ii. listen for up to maximum time T_A for service information sent by another device,

   iii. if T_A timed out, continue with step a. otherwise, check whether said service information sent by another device comprises information about itself (local services); if yes, then continue with step i.; if no, then continue with step a.

2. The method of claim 1, wherein said two devices share a broadcast medium for advertising service offerings.

3. The method of claim 11 or 2, wherein said two devices are part of a local network, preferably a local network with a mesh topology.

4. The method of claim 11 or 2, wherein said two devices form an ad-hoc group.

5. The method of claim 1 or 2, wherein said two devices each broadcast their individual service information in a non-even statistical time distribution.

6. The method of claim 1 or 2, wherein one of said two devices acts as a master and the other as slave.

7. The method of claim 11 or 2, wherein at least one of said two devices is put into a power-saving mode by increasing its timeout value T_A such that a small number of transmissions by said device occur in a give time frame.

8. The method of claim 2, wherein all devices within mutual communication range of each share said broadcast medium.

9. The method of claim 2 or 8, wherein said shared medium is an infrared (IR) channel, a radio-frequency (RF) channel, a HomeRF channel, or a Personal Area Network channel.

10. The method of claim 1, wherein said communications system has a coverage area between a few square meters and a few hundred square meters.

11. The method of claim 1, wherein said service offering is described by means of a service identifier being transmitted as part of said service information.

12. The method of claim 11, wherein said service identifier is a flag or bit combination which describes standard types of services.

13. The method of claim 1 or 11, wherein said service

information comprises a service parameter.

14. The method of claim 11 or 11, wherein said service information comprises expiry information associated with a service offering.

15. The method of claim 14, wherein said expiry information is an expiry time or an age field.

16. The method of claim 14, wherein said expiry information is used to age out the respective service.

17. The method of claim 16, wherein a device removes an expired service.

18. The method of claim 2, wherein said broadcast medium is also used for transmission of user data.

19. The method of claim 1 or 11, wherein said service information comprises a device identifier such as a MAC address.

20. The method of claim 1 or 11, wherein said service information comprises destination information.

21. The method of claim 11 or 2, wherein a first of said two devices receives said service information from the second of said two devices more often than it sends own service information.

22. The method of claim 11 or 2, wherein at least one of said two devices listens periodically for service information.

23. The method of claim 1 or 2, wherein at least one of said two devices alters its transmission probability distribution by reducing its timeout value T_A to make it more likely that it will send service information soon, or increasing it to make it less likely to transmit service information soon.

24. Apparatus (10) for exchanging service information with other devices, comprising a transceiver (13, 14), a processing unit (17), a memory (16) for storing information about its local services and/or services provided by other devices, and a protocol resource manager (11) which

a. triggers said transceiver (13, 14) to send service information, comprising information about itself and/or other known devices to other devices,

b. chooses a timeout value T_A,

c. ensures that the apparatus (10) listens for up to a maximum time T_A for service information received by said transceiver (13, 14),

d. if T_A timed out without having received such service information by said transceiver (13, 14), triggers said transceiver (13, 14) to repeat step a.,

e. if such service information was received by said transceiver (13, 14) prior to T_A timing out, checks whether said service information received comprises information about itself; and

f. if yes, then chooses another timeout value T_A, and continuing with step c,

g. if no, then continues with step a.

25. The apparatus of claim 24, comprising a MAC unit (12) which is employed for the avoidance of collisions.

26. The apparatus of claim 24 being part of a local network, preferably a local network with a mesh topology.

27. The apparatus of claim 24 or 25, wherein said devices form an ad-hoc group.

28. The apparatus of claim 24 or 25, wherein said transceiver (13, 14) broadcasts said service information in a non-even statistical time distribution.

29. The apparatus of claim 24 or 25, wherein said device acts as a master.

30. The apparatus of claim 24 or 25, wherein said device has a power saving unit to put it into a power-saving mode by increasing said timeout value T_A such that a small number of transmissions by said device occur in a give time frame.

31. The apparatus of claim 24 or 25, wherein said device intentionally decreases T_A to increase the number of its transmissions, saving power for all other devices in the group.

32. The apparatus of claim 24 or 25, wherein said device sends empty service information to save power during periods where no advertisements are being received.

33. The apparatus of claim 24 or 25, wherein said transceiver (13, 14) is an infrared (IR) transceiver, a radio-frequency (RF) transceiver, a HomeRF transceiver, or a Personal Area Network transceiver.

34. The apparatus of claim 26, wherein said local network has a coverage area between a few square meters and a few hundred square meters.

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35. The apparatus of claim 24 or 25, wherein said service information is described by means of service identifier.

36. The apparatus of claim 35, wherein said service identifier is a flag or bit combination which describes standard types of services.

37. The apparatus of claim 24 or 25, wherein said service information comprises a service parameter.

38. The apparatus of claim 24 or 25, wherein said service information comprises expiry information associate with a service offering.

39. The apparatus of claim 38, wherein said expiry information is an expiry time or an age field.

40. The apparatus of claim 38, wherein said expiry information is used to age out the respective service.

41. The apparatus of claim 40, wherein protocol resource manager (11) removes an expired service.

42. The apparatus of claim 24 or 25, wherein said transceiver (13, 14) is also used for transmission of user data.

43. The apparatus of claim 24 or 25, wherein said service information comprises a device identifier such as a MAC address.

44. The apparatus of claim 24 or 25, wherein said service information comprises destination information.

45. The apparatus of claim 24 or 25, wherein said protocol resource manager (11) alters the transmission probability distribution of the transceiver (13, 14) by reducing its timeout value T_A to make it more likely that it will send service information soon.

46. The apparatus of claim 24 or 25, wherein said protocol resource manager (11) is implemented in hardware or software, or a combination of hardware and software.

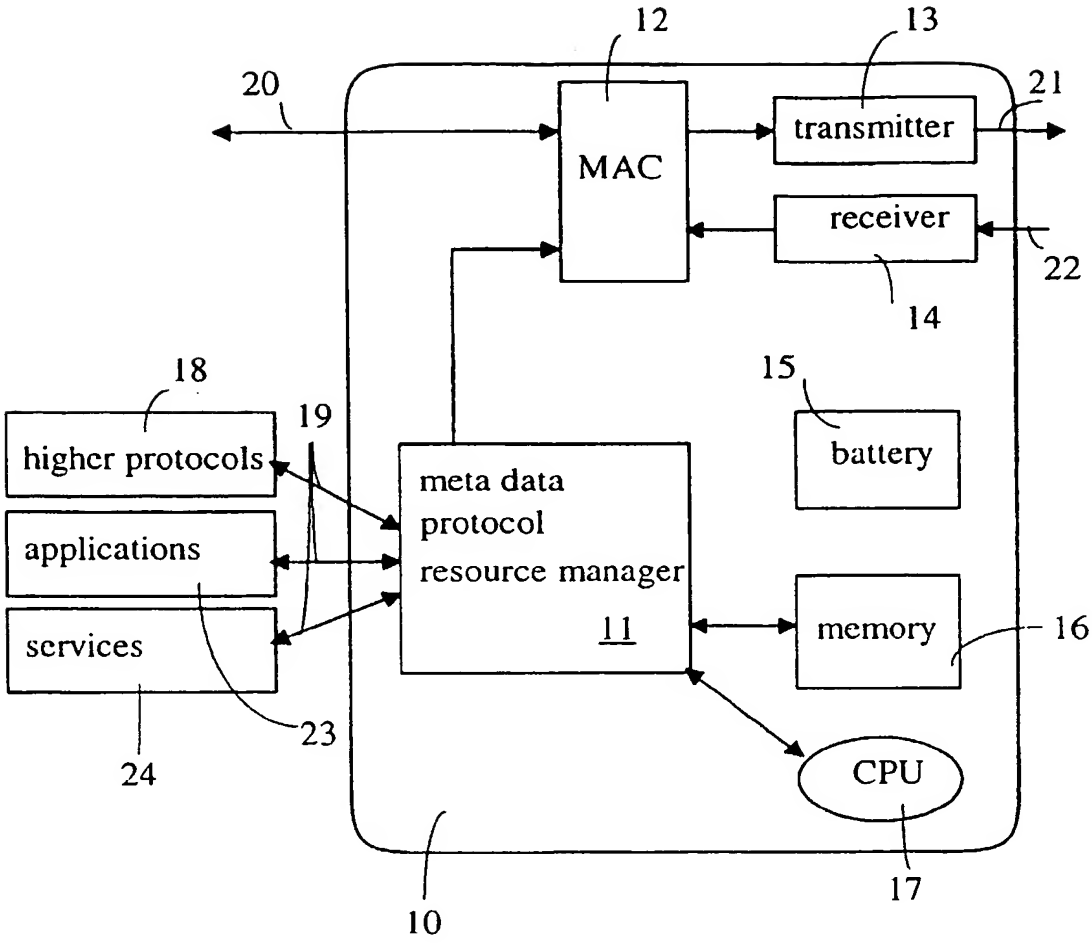

FIG. 1

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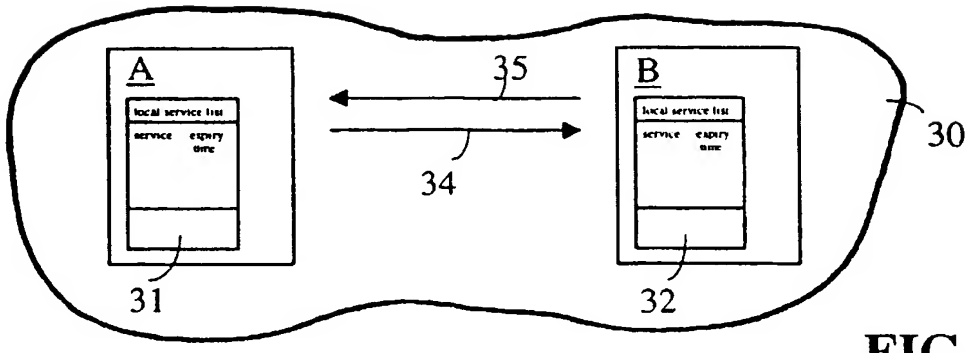
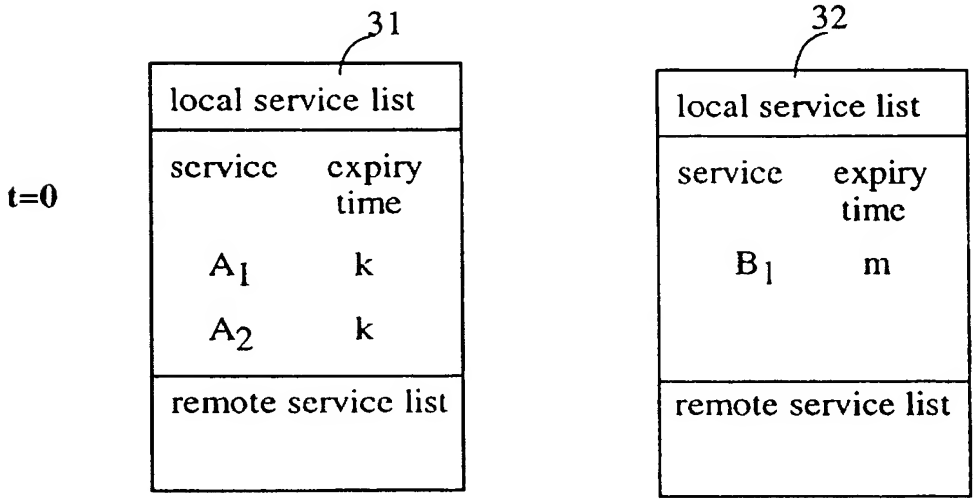
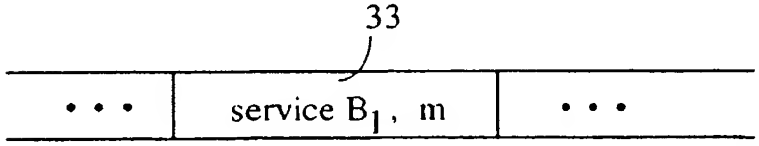


FIG. 2A



t=0

FIG. 2B



t=t_1

FIG. 2C

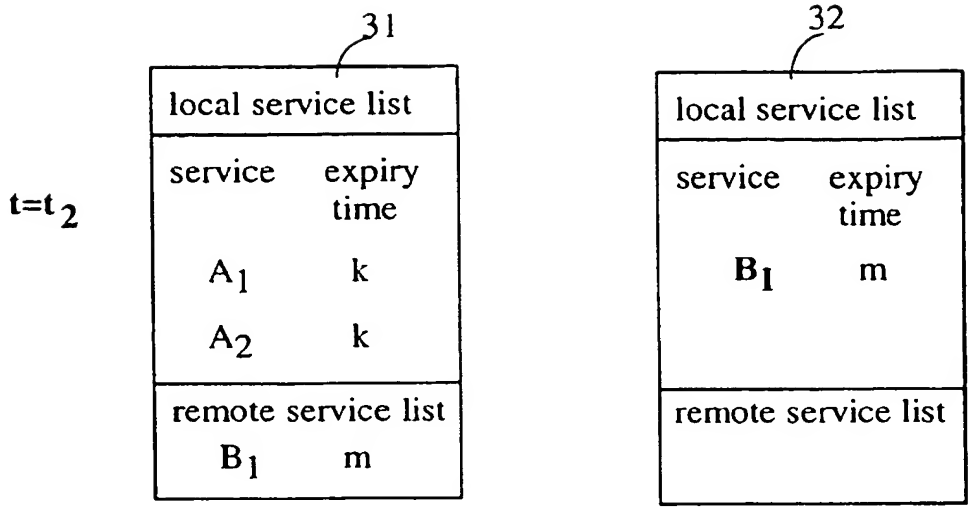


FIG. 2D

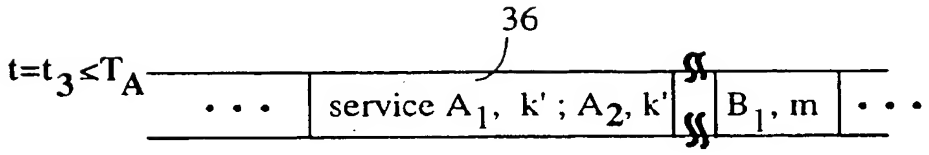


FIG. 2E

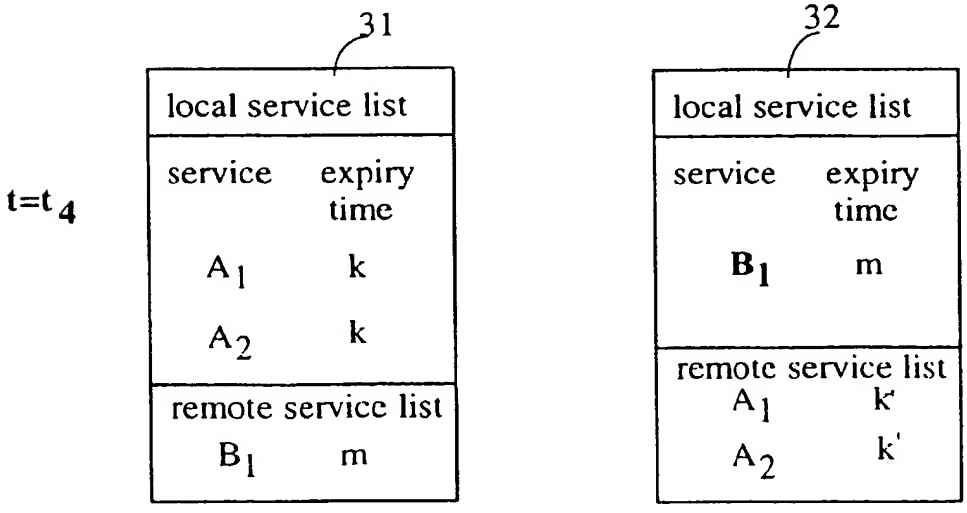


FIG. 2F

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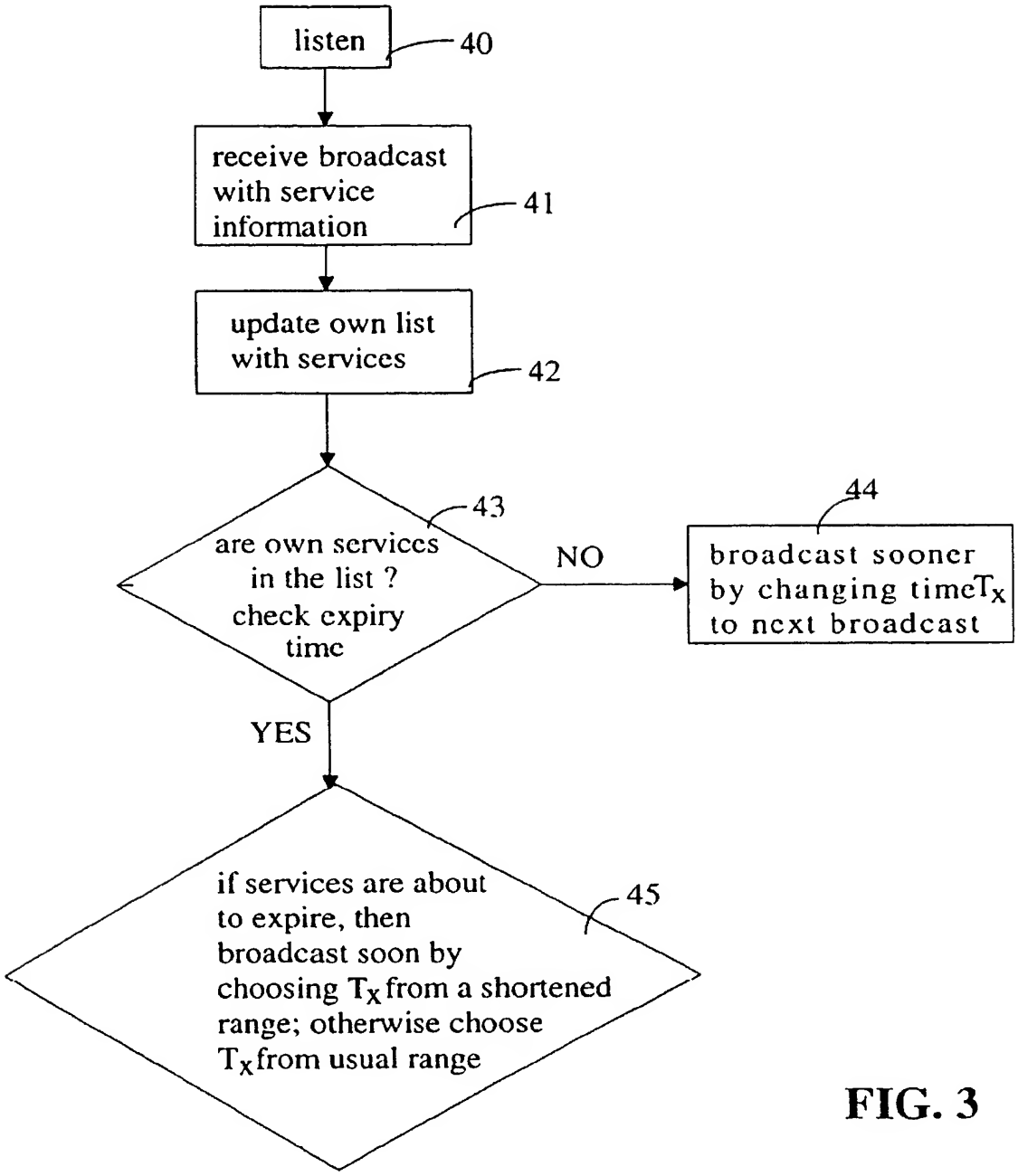
listen
40
receive broadcast with service information
41
update own list with services
42
are own services in the list ? check expiry time
43
NO
broadcast sooner by changing time T_X to next broadcast
44
YES
if services are about to expire, then broadcast soon by choosing T_X from a shortened range; otherwise choose T_X from usual range
45

FIG. 3

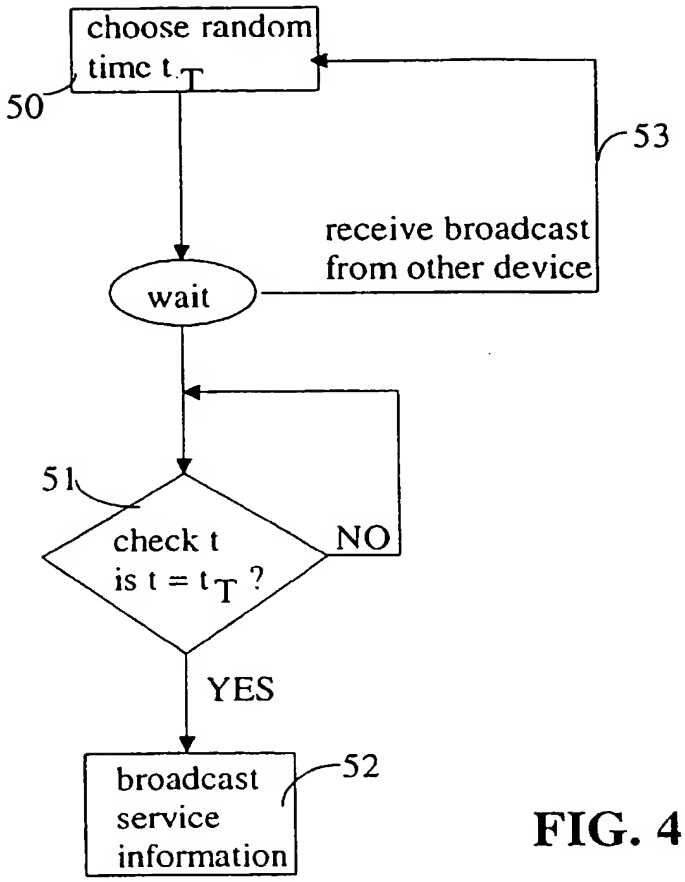

FIG. 4

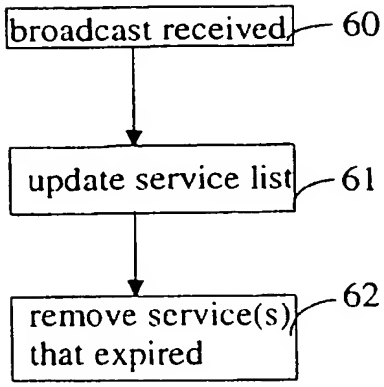

FIG. 5

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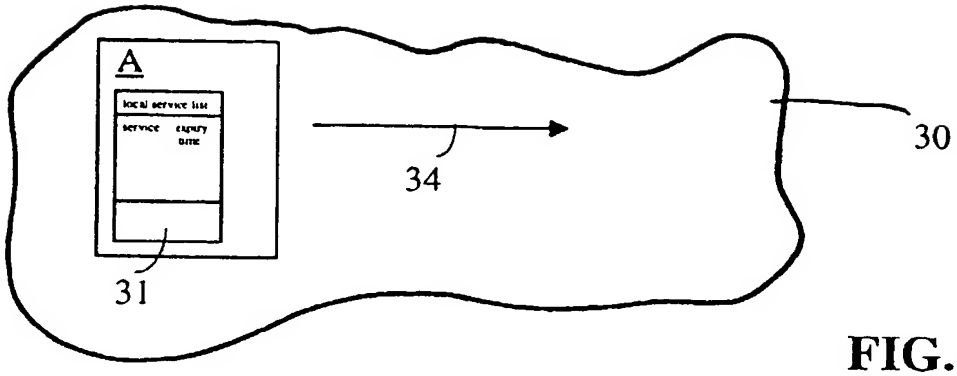

FIG. 6A

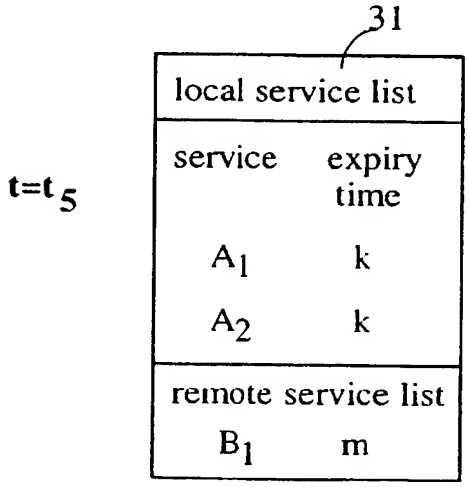

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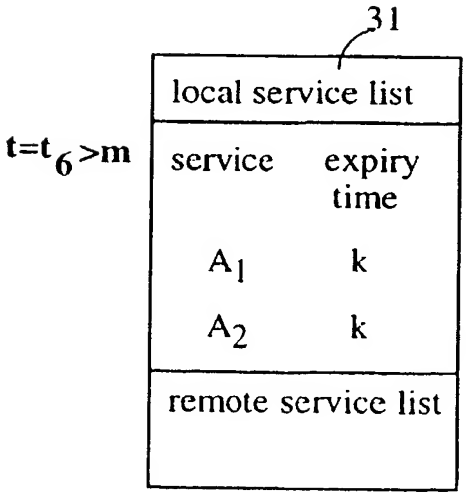
FIG. 6B



$t=t_6>m$

FIG. 6C

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EUROPEAN SEARCH REPORT

Application Number
EP 99 10 1282

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Place of search	Date of completion of the search	Examiner
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